10-1889

Grasses of Mountain Meadows and Deer Parks. Chemical Composition and Tests of Varieties of Strawberries

University of Tennessee Agricultural Experiment Station

BULLETIN

OF THE

AGRICULTURAL EXPERIMENT STATION,

OF THE

UNIVERSITY OF TENNESSEE,

STATE AGRICULTURAL AND MECHANICAL COLLEGE.

Vol. II. OCTOBER, 1889. No. 4.

PART I. GRASSES OF MOUNTAIN MEADOWS AND DEER PARKS.

PART II. CHEMICAL COMPOSITION AND TESTS OF VARIETIES OF STRAWBERRIES.

KNOXVILLE, TENNESSEE,
U. S. A.

THE AGRICULTURAL EXPERIMENT STATION

OF THE UNIVERSITY OF TENNESSEE.

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PART I.

DIVISION OF BOTANY AND HORTICULTURE.

GRASSES OF MOUNTAIN MEADOWS AND DEER PARKS.*

BY F. LAMSON SCRIBNER.

One who has never visited the high mountain regions of the United States, can have little appreciation of the extent and value of the grazing which these regions afford. It is not to the narrow and fertile valleys where good and abundant forage is expected, that reference is made, but to the mountains themselves. Far up on the slopes of these, sometimes on their very summits, are frequent treeless areas, ranging from a few to many hundreds of acres in extent, that are covered with a fine, dense growth of grass, yielding excellent summer pasturage to all kinds of stock. Such mountain meadows abound in the mountains of Eastern Tennessee and Western North Carolina, and "Grassy Bald," a name often heard among the mountaineers, is applied to many of these mountains, because of their grass-covered, but otherwise naked summits. The rich, black soil of these localities, the comparatively low temperature, and especially the abundant moisture which is ever condensing around these mountain tops, keep the close, and even turf, always fresh and green. The high nutritive qualities of this turf for feed is well attested by the fat and sleek appearance of the hundreds, yes, thousands of horses, cattle and sheep which range over these meadows from May to October.

In early summer, stock is driven from the low country, often from points more than fifty miles distant, to these mountain pastures and "grassy balds," where they are kept through the season under the care of herders, whose only duty is to keep the given bands of cattle together.

In Tennessee, the value of these mountain stock ranges is fully recognized, and, as just intimated, they are turned to good account. A consideration of the grasses supplying forage of such value and importance, not only here in the East, but also those which grow in similar meadows in the Rocky Mountains—there called "Deer Parks"—cannot fail to be of general interest.

Through the courtesy of Mr. C. M. McClung, a prominent business man of Knoxville, and a close observer and careful student of our native plants, I was enabled during the last days of July, of the present year, to visit Roan mountain, which stands

*Read before the Society for the Promotion of Agricultural Science, at the Toronto meeting, August 27, 1889.

on the border line between Tennessee and North Carolina, and investigate the grasses of that locality. We found on or near the summit of the mountain—all at an elevation of over 6,000 feet above sea level—twenty-five species of grasses, of which the following is the list:

1. *Phleum pratense, L.*—Timothy.
2. *Agrostis perennans, Tuck.*—Thin-grass.
3. *Agrostis scabra, Willd.*—Hair-grass.
4. *Agrostis rupestris, All.*—Alpine Bent.
5. *Agrostis alba, L.*—White Bent, or Red-top.
6. *Cinna pendula, Trin.*—Nodding Wood Reed-grass.
7. *Brachyelytrum aristatum, Beauv.*
8. *Calamagrostis Canadensis, Beauv.*—Blue-joint grass.
9. *Dactylis glomerata, L.*—Orchard grass.
10. *Eatonia Pennsylvanica.*—Gray.
11. *Glyceria elongata, Trin.*—Long pinnacled Manna-grass.
12. *Poa annua, L.*—Low Spear-grass.
13. *Poa compressa, L.*—Wire grass—Small Blue-grass.
14. *Poa pretensis, L.*—Kentucky Blue-grass.
15. *Poa alsodes, Gray.*
16. *Festuca elatior, L.*—Tall Fescue.
17. *Festuca nutans, Willd.*—Nodding Fescue.
18. *Bromus ciliatus, L.*—Brome grass.
19. *Elymus striatus, Willd.*—Slender Rye-grass.
20. *Asprella Histryx, Willd.*—Bottlebrush grass.
21. *Danthonia spicata Beauv.*—White-top—Wild Oat-grass.
22. *Danthonia compressa Austin.*—Tennessee, or Mountain Oat-grass.
23. *Trisetum subspicatum, var. molle.*—Gray.
24. *Deschampsia flexuosa, Griesb.*—Purple Hair-grass.
25. *Holcus lanatus, L.*—Velvet grass.

Some of these grasses had evidently been introduced, for example, Orchard grass, Tall Fescue, Timothy, and Velvet grass; but all excepting the Orchard grass and Tall Fescue, were well established and apparently, quite at home. The Purple Hair-grass, (*Deschampsia flexuosa*) growing in exposed situations on rocks and ledges, was one of the most showy species, but otherwise of no account. The Low Annual Spear-grass (*Poa annua*) was abundant along the roads and walks and about the hotel. Kentucky Blue-grass (*Poa pratensis*) and Wire grass (*Poa compressa*) were quite generally distributed, and so were the several species of *Agrostis*, (excepting *Agrostis rupestris*) but these, although certainly of some value, formed only an insignificant portion of the forage present, for nowhere did they cover any considerable extent of the surface. The Long Panicle Manna-grass (*Glyceria elongata*) was seen growing rather abundantly along a stream near the

TENNESSEE OAT GRASS—*Danthonia compressa.*

A, Habit of plant. B, Spikelet. C, Flowering glume, dorsal view. D, Palea, dorsal view. E, Seed. F, Seed, seen from edge.

summit; but mention is made of it only to call attention to the discovery of this Northern grass within the Southern States; and for the same reason we may mention the finding of *Trisetum subspicatum var. molle.* The other species enumerated need no further consideration, excepting the species of *Danthonia*, or Wild Oat grasses. *Danthonia spicata*—"White-top"—occupied its usual station in dry soil along the higher ridges and bluffs, while *Danthonia compressa*—Tennessee, or Mountain Oat grass—distinguished by its greener color, much elongated and more abundant leaves, taller culms, more elongated and wider spreading inflorescence, was by far the most abundant grass of all, and the chief component of the luxuriant and dense turf covering the extensive meadows of the treeless areas on the mountain top. The abundance of this grass and the excellent condition of the cattle grazing on it was the subject of remark by the visitors to the mountain, and one at all interested in such matters could not fail to notice it. The chief point of surprise and interest to me was the fact that a *Danthonia* should hold so important and apparently useful a position. Those who have lived on farms in New England, will certainly remember the appearance of "White-top," or "Old fog," as I have some times heard it called—*Danthonia spicata*—and how thoroughly it was despised, not so much because of its own worthlessness as for the reason that its presence indicated poor or "run out" land, and because the yield was so light and the task of mowing it so laborious. As Broom Sedge (*Andropogon Virginicus*) comes in and takes the neglected fields here, so White-top appears and occupies the lands of the thriftless farmer in New England. However, we deemed this grass worth the mowing, and certainly cattle liked it if buyers did not; and since my visit to Roan mountain, our contempt for *Danthonia spicata* has been changed to a measure of respect. I have been led to look closely into the character of these *Danthonias* and find that some of them, from their value as forage plants, deserve our highest consideration. This is the case with *Danthonia compressa*, a grass growing spontaneously along the mountains of the East from the Carolinas and Tennessee North to New England, and wherever it grows abundantly, as it does along the Alleghanies, it affords the choicest grazing. What its possibilities are under cultivation, have yet to be determined. It may prove a valuable grass for permanent pastures in the North and perhaps, also, for the high table lands in the Eastern part of our State. The cool climate and great humidity of the mountain regions are apparently essential to its best growth, aud it is doubtful if the grass would thrive in the low counties where these conditions were wanting. That it would respond quickly to fertilizers, its rank

growth about the droppings of stock on the mountains, is sufficient evidence. In such places, one sees the flowing stems rising to the hight of 2½ to 3 feet, with the lower mass of leaves 18 to 20 inches long. A comparison of *Danthonia spicata* with *Danthonia compressa*, reveals a striking similarity in appearance, and shows their close botanical relationship, but the distinguishing characters of the last named, as already pointed out, mark its superiority for forage.

The great abundance, evident importance and undeniable fattening properties of *Danthonia compressa* so impressed us that we determined to have a chemical analysis made of it, and proper samples for this purpose were gathered and placed in the hands of the Station Chemist, Dr. W. E. Stone, who kindly offered to make the desired analysis. I am indebted to Dr. Stone for the following tables and facts relative to the chemical composition of the grass in question, and its nutritive value as compared with three of our best known and most prized cultivated varieties. Dr. Stone says:

"I find no record of any previous analysis of *Danthonia compressa*. An analysis of *Danthonia spicata* is recorded by Prof. Jordan, in the report of the Maine Agricultural Experiment Station for 1888.

"Two air dried samples of *Danthonia compressa* were analysed: I, consisting of the whole plant cut off close to the root at the time of flowering; and II, composed of the lower tufted growth of the plants, without flowering culms, corresponding to the mountain pasturage.

ANALYSIS.	I. Per cent.	II. Per cent.
Moisture,	9.61	8.50
Dry matter,	90.39	91.50
	100.00	100.00
COMPOSITION OF DRY MATTER.		
Ash,	4.84	3.20
Crude fibre,	32.94	29.80
Protein,	9.75	9.00
Fat,	3.37	4.08
Nit. free extract,	49.10	53.92
	100.00	100.00

"Sample I, included many flowering culms, while II, consisted almost wholly of leaf blades and, as might be expected, the former exhibits about 3 per cent. more crude fibre with 4½ per cent. less nitrogen free extract than the latter. Sample II, represents the forage of the mountain meadows, since by grazing the flowering culms are repressed, and in comparison with recorded analyses of

other standard grasses shows but a small amount of crude fibre and a high percentage of protein, fat and non-nitrogenous matters.

"Strictly, however, only sample I, consisting of the entire plant in flower, can be compared with other recorded analyses. Such a comparison is presented in the following table:

	Moisture	Dry Matter.	Composition of Dry Matter.				
			Ash.	Fibre.	Protein	Fat.	Non Nitrog. Ex't Matter.
Danthonia compressa,	9.61	90.39	4.84	32.94	9.75	3.37	49.10
(1.) *Danthonia spicata*,	8.33	91.67	3.81	34.10	7.49	2.86	51.74
(2.) *Dactylis glomerata* (Orchard Grass.)	8.13	91.87	5.82	41.67	6.89	2.10	48.36
(3.) *Phleum pratense*, (Timothy.)	10.21	89.79	4.67	33.80	6.85	2.36	52.34
(4.) *Agrostis vulgaris* (Herd's Grass.)	8.32	91.68	6.69	32.29	8.18	1.85	50.93

(1.) One analysis, Report Maine Agricultural Experiment Station, 1888, p. 86.
(2.) Average of 4 analyses, Report Maine Agricultural Experiment Station, 1888, p. 112.
(3.) Average of 55 analyses, Report Connecticut Ag'l Exp't Station, 1888, Part II, p. 90.
(4.) Average of 2 analyses, Report Connecticut Ag'l Exp't Station, 1888, Part II, p. 90.

"The two species of *Danthonia* make a most favorable showing beside the others included in the table, and of the two, *D. compressa* is evidently the better. In protein and fat it shows a higher per centage than any of the others, standing much higher than Timothy, while with only one slight exception, (Herd's grass) the fiiber it contains is lower. After making all due allowances for variations in samples, and in conditions, the *Danthonias*, especially *D. compressa*, may safely be classed with our most nutritious grasses."

Thus the chemical analysis of the Tennessee Oat-grass sustains the high opinion formed by seeing its effect upon the stock grazing upon it. It stands well the tramping and grazing of both horses and cattle but sheep are too close feeders, and where these range it soon disappears and there comes up in its place a more or less abundant growth of white or sweet clover.

In the Eastern States are three species of *Danthonia*—the two already mentioned, and the rather rare *Danthonia sericea*, which grows in either dry or damp sandy soil near the coast from Massachusetts southward. This species plays no part in the forage of the country; it is, however, a taller growing plant than the others with stouter culms ,and for certain lands, it may prove to have considerable agricultural value.

I have elsewhere* referred incidentally to the grasses of the mountain meadows or "deer parks" of the Rocky Mountains.

The characteristic grasses of these parks in the Northwest are *Alopecurus occidentalis* or tall American Foxtail, *Festuca scabrella* or Great Bunch grass and again species of *Danthonia*—the chief being D. *unispicata*, commonly known as wild oat grass. This *Danthonia* is often almost the only grass covering the higher "bald" mountains. The rather short but dense turf formed by its close habit of growth and mass of root leaves, strikingly resembles that of grama grass, but the difference in its flowering stems at once distinguishes it. In proportion to the area which it covers on some of the higher mountains, the importance of this grass for grazing is fully equal to that of grama grass on the plains.

Danthonia intermedia is as abundant and more generally distributed than *D. unispicata* and is often seen associated with *Festuca scabrella*. To me this species forms a no less important element in the forage of the parks than *D. unispicata*. In general aspect, it resembles our Eastern *D. sericea*, and some authors have referred it to that species. A taller form of *D. intermedia*, with longer leaves and larger sprikelets grows in Colorado.

Growing with *D. unispicata*, and so far as my own information goes, hardly less common, is *Danthonia Californica*, the largest, most leafy and finest appearing American species of the genus. The *D. unispicata* is thought, by some botanists, to be only a low, few flowered variety of this, but for the purposes of agriculture, we may regard them as distinct.

Sometimes the tall American Foxtail covers the surface of the mountain parks to the nearly complete exclusion of all other grasses. Such an abundant growth furnishes an immense amount of pasturage or hay, and for both these purposes, this fine growing species is especially valuable. It is known to the settlers as "Mountain Timothy," from its general resemblance to our common Timothy, (*Phleum pratense*,) but from which it is easily distinguished by its shorter, thicker, and conspicuously hairy heads. As there is a true Mountain Timothy, (*Phleum alpinum*) and as this *Alopecurus* is very closely allied to the English Foxtail, it would be better to call it tall American Foxtail, or simply American Foxtail.

Great Bunch grass, or Buffalo Bunch grass as I have heard it called in Montana, is a more abundant species than either the Danthonias or Foxtail, and is correspondingly more valuable as an element of forage in the mountain meadows. It frequently covers these as well as the higher foot hills with a turf almost as

* "Agricultural grasses of Central Montana," Proc. Soc. Prom. Agr. Sci. 1883, and "Agricultural grasses of Arizona" l. c. 1885.

close and dense as that of our eastern pastures, but its habit of growth is to form bunches or clumps several feet in diameter, and from these it sends up flowering culms from the height of three to four, or even five feet. It is frequently cut for hay, for which purpose it is admirably adapted, although considered inferior to the native "blue joint," (*Agropyrum glaucum*) of the "bench lands" and river bottoms.

These grasses—the tall American Foxtail, the great Bunch grass and the species of *Danthonia*—are, for all practical considerations, *the* grasses of the "deer parks" of the mountains of the Northwest. There are other grasses which afford considerable forage, but which, in comparison with those I have named, hardly deserve mention. Among these are several varieties of *Festuca ovina*, *Poa nemoralis*, *Poa alpina*, *Poa reflexa*, and especially *Poa Californica*, some mountain species of *Agostis* and *Melica bulsosa*.

Towards the South, in Arizona, the species of *Danthonia*, as well as the Foxtail and great Bunch grass disappear, and their place is taken by species of *Muhlenbergia*, such as *Muhlenbergia gracilis* and the soft and leafy *Muhl. virescens;* these, together with the more luxuriant Southern forms of *Poa Californica*, constitute the bulk of the forage of the so-called "deer parks" in that latitude.

The species which I have enumerated are all native and characteristic of the mountain meadows. In more senses than one, they occupy an exalted position in grazing resources of our best grazing regions. I am not aware that the nutritive value of any them has been determined by chemical analysis, save that of *Danthonia compressa*, here given, but the true test of their value is in the avidity with which they are eaten by stock and fine condition of the cattle, as I have observed both in the East and West, which graze upon them.

PART II.

CHEMICAL DIVISION.

I. CHEMICAL COMPOSITION OF STRAWBERRIES.

By W. E. Stone.

Very few references to the chemical characteristics of the strawberry are to be found in the literature. This seems none the less noteworthy because of the attention devoted to this fruit in other directions, and because of the importance it has attained as a commercial and edible product. In general, however, the whole series of small fruits has secured slight attention from agricultural chemists, and this is in a measure unfortunate, because it is a notorious fact that just these products are more susceptible of change and improvement, by variation of conditions, than any other. The differences between our wild and cultivated fruits with regard to their taste and flavor are based on changes brought about in their chemical composition. These improvements have been largely due to the efforts of horticulturists working through the channels of selection and hybridization. The effects of different classes of fertilizers or of other conditions, upon the composition of such fruits, and, indeed, what their composition in general may be under any circumstances, has hardly been touched upon by investigators.

It seemed, therefore, a matter of decided interest, as a contribution to our knowledge of the strawberry, to study the ripening crop at the Station farm with as much minuteness as circumstances would allow. The immediate object of the investigation was to determine the nature and amount of the important chemical constituents, in each of the varieties at hand, such as water, dry matter, sugars, acids, ash, fiber, fat, protein and nitrogen—free extractive matters—in short, those constituents which control the agreeableness of taste and flavor and the value as a food, of all fruits. The peculiar aroma, which is a specific characteristic of the strawberry, is of such delicate and volatile nature that its quantitative determination would be a matter of utmost

difficulty, and it was not attempted. The determination of the substances indicated above, furnish data which may be used:

1°. For a comparison among themselves of the different varieties studied.

2°. As a contribution to the knowledge of what the average composition of the Strawberry is, which, on comparison with other fruits, will indicate their relative food values.

3°. As facts for reference with which to compare the composition of strawberries grown under other conditions of climate, soil and fertilization.

4°. As a means of indicating the degree to which the cultivated strawberry has been improved beyond the wild one, and of fixing a point from which any subsequent development may be measured.

The material for the investigation included twenty varieties of strawberries growing upon the Station grounds. The fruit ripened, and samples were taken during the last days of May. Care was taken to select only ripe specimens of average size and sound condition. The samples as soon as received at the laboratory were hulled and separated into two portions, one of which served for the immediate determinations of moisture, free acids and sugar. The other portion was dried and was used later for the determination of the so-called food constituents.

WATER AND DRY MATTER.

From 15 to 20 grains of the fresh fruit, of each variety, were sliced thin, loosely laid in a tared beaker glass and dried, at first, at a temperature of 98° C., and eventually a short time at 105° C., until approximately, a constant weight was obtained. The percentage of loss during this process represents the amount of *water* contained in the fresh fruit; the residue is the *dry matter.*

In the case of the strawberry, this determination is somewhat difficult, owing to the peculiar behavior of the fruit, which appears to melt at a temperature of about 50° C., the tissues collapsing and the juice flowing out, to become by continued heating a thick gummy syrup. In this state it is hard to bring the material to complete dryness.

The following table shows the results of these determinations:

Varieties.	Date of Collection.	Water Expelled at 105° C.	Dry Matter Remaining at 105° C.
		Per cent.	*Per cent.*
Indiana,	May 21,	91.51	8.49
Jumbo,	May 21,	90.83	9.17
May King,	May 22,	90.13	9.87
Agriculturist,	May 22,	91.25	8.75
Cornelia,	May 23,	90.42	9.58
Legal Tender,	May 23,	90.29	9.17
James Vick,	May 23,	89.68	10.32
Iron Clad,	May 23,	89.58	10.42
Perry,	May 24,	91.03	8.97
Bidwell,	May 24,	89.43	10.57
Primo,	May 24,	89.98	10.02
Mt. Vernon,	May 24,	91.26	8.74
Nameless,	May 25,	92.43	7.57
Mrs. Garfield,	May 25,	91.22	8.78
Kentucky,	May 25,	87.72	12.28
Jucunda,	May 25,	90.44	9.56
Perry's Seedling,	May 27,	89.71	10.29
Boone,	May 27,	91.35	8.65
Manchester,	May 28,	91.05	8.95
Woodruff,	May 28,	91.14	8.86
Average,		90.52	9.48

The variations between the different sorts are included within the limits of two per cent. (in one exceptional case four per cent.) a difference which is, practically, very small. Probably an equal variation would be observed between as many different samples of the same sort. The averages may be assumed to fairly represent the normal composition of the strawberry, viz., nine and one-half per cent. of dry matter and ninety and one-half per cent. of water. The strawberry is therefore essentially a watery fruit, less than one-tenth its weight being solid matter. In this connection it will be of interest to quote the few available data with regard to other fruits.

Apples contain 16 to 20 per cent. of dry matter.
Pears contain 15 to 20 per cent of dry matter.
Peaches (flesh) contain 11 to 14 per cent. of dry matter.
Plums (flesh) contain 18 to 20 per cent. of dry matter.
Currants contain 11 to 14 per cent. of dry matter.
Blueberries contain 18 per cent. of dry matter.
Grapes contain 15 to 25 per cent. of dry matter.

From which it appears that the strawberry occupies the lowest place in the scale of comparisons.

SUGAR AND ACID.

For the determinations of sugar and acid, from 80 to 100 grams of the fresh fruit were weighed out, thoroughly crushed in a mortar, the whole mass transferred without loss to a flask, cold water added to a volume of 350 c.c., thoroughly shaken and allowed to stand fifteen minutes. The practically homogeneous mixture thus obtained, was then filtered rapidly with the aid of a pump, the clear filtrate having the peculiar strawberry color. This solution served for the determinations of sugar and acid.

Two kinds of sugar commonly occur in fruits in varying proportions; the one, *glucose*, has the formula: Carbon 6, Hydrogen 12, Oxygen 6; it is recognized and determined quantitatively by its action upon an alkaline copper solution, known as "Fehling's solution." The other, *cane sugar* or *sucrose*, has the formula Carbon 12, Hydrogen 22, Oxygen 11, and does not act upon "Fehling's Solution."

By treatment with dilute acids, glucose is unchanged, but cane sugar becomes transformed into glucose. By treating the strawberry juice directly with "Fehling's solution," the amount of glucose is determined.[1] A second measured portion is treated with dilute acid and then with "Fehling's solution," the increase of glucose in the second test being ascribed to the cane sugar, which has been converted into glucose. From these data it is easy to calculate the amount of cane sugar originally contained in the solution. This method was followed in obtaining the results given below. One portion of the solution was treated directly; another measuring 50 c.c., received 5 c.c. of concentrated hydrochloric acid ("inversion") and was kept at a temperature of 65° C., during half an hour. The solution was then neutralized with caustic soda and treated with "Fehling's Solution." In the following table, the increase in glucose obtained by this process is given as such, and is also calculated as cane sugar. The amount is very small and there are very good reasons for believing that cane sugar does not exist in the strawberry, chief of which is the presence of free acids in the fruit which would act to convert any cane sugar which might be formed into glucose. The slight increase of glucose by treatment with acids may be ascribed to the presence of the other substances of a gummy or pectose nature, which are well understood to form sugars which act upon "Fehling's solution," when treated with strong mineral acids, but which are not sensitive to the weaker organic acids of the fruit.

1. The glucose determinations were made by titration, according to Soxhlet's method. 10 c.c. of Fehling's Solution were diluted with two volumes of water, and brought to boiling. While still boiling, the solution of strawberry juice was run in from a burette. The mixture was then boiled exactly two minutes and tested for an excess of sugar or copper, as the case might be. Usually four or five tests suffice to fix the result accurately.

Furthermore, a special effort was made to isolate cane sugar from the strawberries by means of certain recognized methods, [2] but these failed to yield any appreciable trace.

For commerce, and as a matter of record, both sets of numbers are given below—those indicating increase of glucose and the same recalculated as cane sugar:

Variety.	Glucose Present in Fruit.	Glucose after Inversion.	Difference.	Difference Calculated as Cane Sugar.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Indiana,	4.41	5.31	0.90	0.86
Jumbo,	3.91	4.81	0.90	0.86
May King,	5.25	6.03	0.78	0.74
Agriculturist,	4.05	5.21	1.16	1.10
Cornelia,	4.30	5.12	0.82	0.78
Legal Tender,	6.71	6.73	0.02	0.019
James Vick,	4.41	5.63	1.22	1.17
Iron Clad,	4.76	5.81	1.05	1.00
Perry,	4.75	4.94	0.19	0.18
Bidwell,	4.28	5.06	0.78	0.74
Primo,	4.89	5.16	0.27	0.26
Mt. Vernon,	5.08	5.20	0.12	0.11
Nameless,	5.13	5.40	0.27	0.26
Mrs. Garfield,	5.73	6.52	0.79	0.75
Kentucky,	5.77	6.59	0.72	0.68
Jucunda,	4.93	6.08	1.15	1.09
Perry's Seedling,	4.16	4.95	0.79	0.75
Boone,	4.33	4.39	0.06	0.05
Manchester,	4.83	5.39	0.46	0.44
Woodruff,	3.98	4.84	0.86	0.82
Average,	4.78	5.46	0.62	0.58

The variation of actual glucose in the different sorts is within limits of about two and three-quarters per cent. The amount of *apparent* cane sugar is, with three exceptions, less than one per cent—on the average only about one-half per cent.

Comparing these average results with those relating to dry matter, it is apparent that about one-half the dry matter of the strawberry is composed of glucose. Comparison with other fruits, it is also favorable to the Strawberry, although many of the former contain considerable cane sugar in addition to the glucose given.

2. 1°. By extraction with boiling alcohol, concentration of the extract and crystallization.
2°. By treating the juice of the berries in considerable quantities with strontium oxide. (*Die Landwirthschaftlichen Versuch-Stationen*, XXXIV, p. 408.)

Peaches contain 1 to 2 per cent glucose.
Apricots contain 2 to 3 per cent glucose.
Plums contain 2 to 4 per cent glucose.
Raspberries contain 4 to 7 per cent glucose.
Sweet cherries contain 10 to 11 per cent glucose.
Grapes contain 10 to 30 per cent glucose.
Apples contain 7 to 8 per cent glucose.

In the solution described above the acids which were present in a free state, *i. e.*, uncombined with bases, were determined by treating a measured quantity of the solution with an alkali of known strength until the solution became neutral. [3]

The natural coloring matter of the strawberry is sensitive to the action of alkalies, the point of neutralization being marked with considerable distinctness by the changing of the rose color to a brownish tint.

The acid indicated by the results below exist as a mixture of several kinds, of which probably *citric*, *tartaric* and *malic* predominate. These are common to nearly all fruits, sometimes one, sometimes another being more abundant. For instance, malic acid predominates in the apple; citric acid in the orange and lemon, and tartaric acid in the grape; smaller quantities of the other acids being also present. The quantitative determination with alkali does not distinguish between these different acids but simply indicates what is required to neutralize them. Such results are given in the first column of the following table. A subsequent study of these acids has shown that while small quantities of citric and tartaric acid may be present, the prevailing acid of the strawberry is malic. This furnishes a constant factor from which it is possible to calculate the percentage of free acid in the original substance of the fruit with a considerable degree of accuracy. Upon this basis, therefore, the numbers of the second column are prepared:

3. 10 c. c. were diluted with three to four volumes of water and titrated with tenth-normal potassium hydrate, using phenolphtalein as an indicator.

Varieties.	Amount of Tenth-normal Potassium hydrate required to neutralize 1 gram of fruit.	Percentage of free acid, calculated as malic.
	Cub. cent.	*Per cent.*
Indiana,	2.06	1.38
Jumbo,	2.04	1.37
May King,	1.78	1.18
Agriculturist,	1.85	1.24
Cornelia	1.57	1.05
Legal Tender,	2.21	1.48
James Vick,	2.00	1.34
Ironclad,	2.60	1.74
Perry,	2.20	1.47
Bidwell,	2.33	1.56
Primo,	2.34	1.57
Mt. Vernon,	1.82	1.22
Nameless,	1.94	1.30
Mrs. Garfield,	1.85	1.24
Kentucky,	2.83	1.90
Jucunda,	2.12	1.42
Perry's Seedling,	2.17	1.45
Boone,	1.60	1.07
Manchester,	2.03	1.36
Woodruff,	1.62	1.09
Average,	2.5	1.37

Here again the variation between the different sorts is very slight, altogether between limits of less than one per cent. For comparison with the average of 1.37 per cent., the following average data relating to other fruits are presented:

Apples contain 0.8 per cent of free acid.
Pears contain 0.2 per cent of free acid.
Plums contain 0.9 per cent of free acid.
Currants contain 4 to 7 per cent of free acid.

FOOD CONSTITUENTS.

A portion of the fresh fruit as received at the laboratory, was hulled and dried, to be used afterward, for the determination of the so-called food constituents, comprising the ash, fibre, fat, nitrogenous matter, and the non-nitrogenous extract. As already noted, the peculiar behavior of this fruit when heated, prevented the drying of these samples in the usual way, viz., by means of artificial heat. By drying on plates in the sunshine, all the samples, with three exceptions, were brought to a condition in which they could be preserved indefinitely. The fruit thus prepared was of a gummy, pasty consistency, resembling dried figs in condition and very remarkably so in taste. If it were possible to

dry the strawberry quickly and cheaply, it would produce, if cured for instance like the fig or raisin, a pleasant and desirable "sweet." In the condition noted above, they contained about 20 per cent of moisture and were apparently as resistant toward mould or fermentation as figs or raisins.

In the following table the amounts of the various food constituents contained in the *dry matter* of the fruit are given, i. e., the sum of these items, or percentages with each variety, make up 100 parts of the dry matter of the original fruit. By multiplying these items by the percentage of dry matter for the variety to which they relate, their percentage in the original fresh fruit will be obtained. The terms used: "ash," "fibre," "ether extract;" etc., have been explained in Bull. 3, Vol. I, of this Station.

COMPOSITION OF DRY MATTER.

Varieties.	Crude Ash.	Crude Fibre.	Ether Extract.	Crude Protein.	Non-Nitrogenous Extract.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Indiana,	7.22	14.90	6.46	12 17	59.25
Jumbo,	6.01	14.92	6.60	10.41	62.06
May King,	6.74	14.41	6.26	11.19	61.40
Agriculturist,	6.66	13.46	7.07	11.17	61.64
Cornelia,	6.56	16.06	4.97	9.83	62.58
Legal Tender,	6.33	13.71	6.41	10.17	63.38
James Vick,	6.01	17.89	6.74	9.53	69.73
Perry,	6.12	11.54	5.86	9.45	73.03
Bidwell,	6.41	18.80	8.07	11.66	55.06
Primo,	6.86	16.77	6.92	10.88	58.57
Nameless,	5.79	19.17	8.31	9.99	56.74
Mrs. Garfield,	6.55	14.52	6.44	10.76	61.73
Kentucky,	5.92	13.41	7.39	8.24	65.04
Jucunda,	7.62	23.71	8.38	11.30	48.99
Perry's Seedling,	7.95	17.46	4.99	10.76	58.84
Boone,	8.07	22.71	9.12	10.16	49.94
Manchester,	4.16	14.53	4.81	10.98	65.52
Averages,	6.53	16.35	6.75	10.51	60.79

These numbers relate to the entire fruit inclusive of the seeds, which were not separable from the pulp of the fruit. Since the seeds largely escape digestion, however, the above composition is somewhat different from that presented to the stomach, and probably shows a larger proportion of ash, fibre, ether extract and protein and less non-nitrogenous extract than belong to the really digestible portions of the fruit. If we reduce the averages of the above table to the basis corresponding to the fresh fruit, with an average of only 9.48 per cent. dry matter, we have the following statement of what the actual amounts of the different constituents of the strawberry are:

	Per cent.
Water,	90.52
Dry matter,	9.48
Contained in dry matter—glucose,	4.78
Increase of glucose by inversion, calculated as cane sugar,	0.58
Free acid, as malic,	1.37
Ash,	0.62
Crude fibre,	1.55
Ether extract,	0.64
Crude protein,	0.99
Non-nitrogenous extract,	5.76

Considered as a food, therefore, the strawberry would hardly be rated as very nutritious. The small amounts of food constituents present are so diluted by the ninety per cent. of water, that to sustain life a very large quantity would have to be consumed. The office of this as well as other fruits is not, however, so much one of nutrition as that of supplying the beneficial vegetable acids to the system, diluted and flavored by the water and sugar and delicate fruit aroma, the combination of which, in the case of the strawberry, has attained so delightful a degree of perfection.

Several analyses of European strawberries are on record,[4] from which we may quote the following averages: The fresh fruit contained, water 87.66 per cent.; total sugar 6.28 per cent.; free acid 0.93 per cent.; protein 0.57 per cent.; fibre 2.32 per cent.; ash 0.81 per cent. From this it would seem that the European berry is sweeter than the American, but contains less protein and more fibre.

It is to be regretted that circumstances prevented the examination of the wild strawberry simultaneously with the varieties given, in order that data might have been acquired for illustrating the improvement made in the cultivated sorts. From other sources very little is to be derived. The proportions existing between the acid and sugar in the wild and cultivated fruits are probably more indicative of this change than any other feature. In the varieties examined the average proportion of acid to sugar was 1. to 3.5. For the wild strawberry the only references available, and these very meagre, show a corresponding proportion of 1 to 2.[5] This indicates that a change for the better has been made, but it is far from probable that the limit has been reached. Size and firmness of fruit have been successfully sought for. A similar increase of sweetness and concentration of flavor would wonderfully advance the desirability of some the choicest varieties, and it would seem as if this were to a certain degree possible.

4. Chemie d. Mensch Nahrungs u. Genussmittel, J. Konig. I Band, 3d Edition 1889 p. 777.

5. C. A. Goessmann, Rep. Mass. State Board of Agriculture, 1879-1880. H. A. Weber, Journal Columbus Horticultural Society, June, 1887.

DIVISION OF FIELD AND FEEDING EXPERIMENTS.

II. TESTS OF VARIETIES OF STRAWBERRIES.

By C. S. Plumb.

The following varieties have been tested, more for practical purposes than scientific, and while the notes taken are fairly accurate, they do not go much beyond a practical application for the farmer. The varieties tested were not simply a dozen plants, but covered two and one-half acres of ground. Consequently the notes are based upon the field development of the plants, the berries of which were sold in the market. And it is believed that the reader can place confidence in any recommendation of varieties, as applied to East Tennessee and this locality.

The strawberry field is practically level, and consists of a retentive clay-loam in a high state of cultivation. The plants were grown in rows three and one-half feet apart, being one foot apart in the row. The berries reported upon represent the first crop the plants have ever produced.

The following notes explain themselves:

Agriculturist. Plants of medium size, which produce runners abundantly. The foliage has been healthy as a rule, is dark green in color, of medium size, oval, and thin in texture. Ripe berries are medium deep red in color, small, longer than broad, rather triangular, and usually tapering abruptly to a point. The flesh is tender, of very good flavor, sweet and mildly sub-acid. The present test, as well as previous ones upon the college farm has shown this variety to be a shy bearer.

Bidwell. The plants are quite robust and healthy, producing pale green, thick, small, oval leaves. In the fall the leaves turn bronze-green. The plants are not very productive. The berry is almost twice as long as broad; somewhat oval in form, being larger at the center than at base or tip. The basal third of the fruit is quite devoid of seeds. Berry is of good flavor, sweet and mildly sub-acid, and when fully ripe is a dark, glossy red. We rank this as first-class in quality, and third-class in productiveness.

Boone. Plants fairly strong, producing leaves of medium size, of thin texture, that in the fall are dark bronze-green. The fruit is dark red, and when fully ripe the flesh is dark through to the

center. The berry is conical, with a blunt tip, the surface of which is quite thickly covered with seeds. This is a poor table fruit, and is not desirable.

CHARLES DOWNING. This variety has a dark green, vigorious foliage, with small leaves, which are oval and of medium size. A sweet, tender, first-rate berry, medium to dark red in color, and of good flavor. Form usually conical, and surface of berry covered with a medium amount of seed. Is a desirable berry.

CORNELIA. Plants of average vigor, and not very productive, low growing, clustering, with healthy, small, oval, dark bronze, green leaves, in the fall. When ripe, the berry is dark red in color, with a glossy surface, on which are raised many seeds. The flavor of the fruit is strongly sub-acid, and often insipid. One side of the berry, when ripe, is usually white or pale red. Berries oval, quite regular in shape, having a blunt point. This variety is evidently not the Cornelia that is grown at some other Stations.

DAISY MILLER. The plants are strong, and have covered the ground about the rows with a profusion of young plants. The foliage is medium dark green, large, oval, of coarse texture, dark green, and is rather inclined to suffer from blight. Form of berry broadly oval, medium deep red in color, and having tender flesh. Flavor rather inferior, and neither sweet nor strongly acid. This variety is quite productive, and on June 6, the plants contained many small, green berries, as well as some blossoms. However, the quality of the fruit is not sufficiently high to recommend it.

GARRETSON. The fruit is bluntly conical in shape, tapering gradually from the base, is pale red in color, and the surface is comparatively few seeded. The flavor is sweet, yet insipid, lacking character. It is not a desirable variety.

INDIANA. The plants are very robust and reproduce from runners most abundantly. Leaders profuse, of medium size, dark green, obovate, thin. Fruit conical, being larger at the base than elsewhere, quite regular in form, and is usually rather solid, of fair size, though not large. When ripe, the berry is pale red in color, of good—though not first quality—flavor, and is pleasantly acid. The berry frequently inclines to hairiness. Ripe on May 11; on May 27, it was in its bearing prime. It produces abundantly here, and is a good market berry.

IRONCLAD. Plants large, stout, vigorous, of deep green color. The leaves are large, thick, obovate. The berry is conical, usually tapering from its lower third to the tip, is longer than broad, fairly constant in shape, of medium size, is usually well studded with seeds, and is pale red in color. Flavor poor and rather acid. Without doubt, this is the most vigorous of any

variety we have grown, yet from its introduction upon the College farm, years ago, it has not been a success, either for productiveness or quality. Yet its foliage is especially robust, and can be readily distinguished across the field, over all others. With blight affected varieties on both sides, it is not diseased in the least.

JAMES VICK. This variety has not done well, the plants making an irregular growth, though when well developed, they are quite productive. The leaves are large, oval, pale green in color, and have suffered quite badly from blight. Fruit rather conical, tapering abruptly from a broad base, usually irregular in form, and broader than long, with a medium sharp tip. The surface of the berry is slightly glossy, is studded with more than the common number of seeds, and when ripe is of medium size, deep red in color. Flavor inferior, strongly sub-acid.

JERSEY QUEEN. Plants fairly strong and productive. Leaves round, dark green, medium size, thin texture. Fruit regular in form, rather roundish or very bluntly conical, and medium red in color. Fruit tender, very juicy, of good flavor, mildly sub-acid. Is rated by us as an excellent variety, producing abundantly of large, desirable table fruit, of better than average quality.

JUMBO. This is a vigorous growing variety, that multiplies its plants most abundantly, and produces a good crop. The leaves are thick, dark green, oval. The berry is usually shiny, medium light red when ripe, is broad at the calyx end, and round at the tip, being broader than long. We have usually found the berries solid, even in extra large ones. Size is larger than average. Flavor good, pleasantly sub-acid. As grown here, is better than the average berry for market or home use.

JUCUNDA. The plants of this variety have been badly affected by rust. The foliage is coarse and the plants lie low to the ground, inclining to a profuse growth. The leaves are large, round, dark green, coarse. Form of fruit is irregular, but generally conical. Color pale red, flavor fair, sweet, mildly sub-acid, flesh tender yet firm. This is a fair berry when fruiting well, but does not appear desirable here.

KENTUCKY. Plants pale green, quite tall, not very prolific, either in berries or plants. Leaves small, pale green, but in fall becoming darker in color. Fruit conical, tapering from base to tip, pale red, coarse, rather acid, with a tendency towards large seeds and hairiness. This variety has nothing desirable about it.

LEGAL TENDER. Plants quite erect, with foliage healthy and strong. Leaves small, coarse, dark green, oval. Fruit conical,

tapering gradually from base to a fairly sharp point, longer than broad, sometimes irregular. The ripe berry is of a dull, deep red color, is usually well colored from base to tip, is of good flavor, sweet and mildly sub-acid. This berry is small, as a rule, and I should class it as second-rate.

LONGFELLOW. The form of this variety is the reverse of long, being much broader than long. It is small in size, of poor flavor, and is strongly sub-acid. Color medium light red. Is not at all desirable.

MANCHESTER. The plants produce abundantly, but are not thrifty growers, as a rule. Foliage light green, with a bronze tint in the fall, thin, small to medium. Berry medium to dark red in color, broader than long, tapering abruptly or rounded at the tip, small to medium in size, usually solid. Flavor good, pleasantly sub-acid when well ripened. This variety has done poorly with us, and we cannot recommend it.

MAY KING. Plants very healthy, having a deep rich green foliage, of large, oval, thin leaves. Form conical, about as long as broad, with each of the two sides as long as the base; size about the average; color bright pale red, very evenly distributed over the ripe fruit; surface rather smooth, owing to the seeds being rather below the surface of the fruit. Flavor quite pleasant, being sweet or mildly sub-acid. While this variety does not produce as abundantly as some, the fruit is large, fairly abundant, and is first quality as grown here. We do not hesitate to recommend this variety, especially for home use.

MRS. GARFIELD. Leaves large, round, fine in texture, and bronze green in the fall. Form of fruit conical, tapering gradully, longer than broad, with greatest diameter often in the center. Surface of berry sparsely seeded, and smooth, deep red in color. Flavor sweet, mildly sub-acid, flesh tender and good.

MOUNT VERNON. The plants have been troubled some with blight. Foliage coarse, light green in spring, darkening in the fall; leaves round, of medium size, finely serrate. Fruit conical, blunt pointed, pale red, very seedy. Flavor fair, though with an insipid tendency, sub-acid. Is just barely medium. Is not very productive.

PARRY. Large, robust plants, that multiply from runners rather sparingly. Leaves thin, oval, bronze-green in the fall. Form of berry rather variable, but often conical, rather thickly studded with seeds, color dark red, extending through the flesh when ripe. Flavor fine, sweet, mildly sub-acid, with tender flesh.

This is an excellent fruit, but is not especially productive. It has not succeeded very well with us, as it has suffered some from blight.

PRIMO. Plants small and low. Leaves few, small, dark green, thin, oval. Form bluntly conical. Fruit very watery and of insipid flavor. Is not at all recommendable.

PRINCE OF BERRIES. The foliage inclines to a pale green color, and is rather fine. The plants are especially productive. Fruit usually large and round at the tip, and contracted and slender at the calyx end, thus forming in a measure a neck next to the stem, which makes it especially easy to hull. Berry not large, is quite early, and holds its fruit well, lasting till late in the season. Color medium red. The flesh is of unusually fine flavor and tenderness.

SHARPLESS. Foliage vigorous, and the plants increase in numbers rapidly. Leaves light green with a bronze hue in the fall, of thin texture and oval shape. The berry is broader than long, often twice as much so; irregular, being ridged or doubled, often; point frequently broad. Color of ripe berry deep red at base, with gradual decadence of intensity of color, till the lower third or tip is greenish-white. One side of the fruit is also often whitish. Flavor pleasant, sweet or mildly sub-acid. Without doubt, the best berry grown at the Station this year, from points of vigor, productiveness and quality of fruit.

WOODRUFF. Leaves large, coarsely serrate, light green. Form long, tapering, ridge tipped. Surface of berry thickly studded with seed. Flavor sub-acid and inferior, not very sweet, flesh somewhat red within. Is not a desirable variety to grow for any purpose.

The table below contains some information of a useful nature. The time of blossoming was not recorded until several blossoms had appeared, and several berries were ripe before a record was made of ripeness. In weighing the berries, only average ones were selected, and these were not all of the same size, but rather as one might find them in a fair sample in the market.

Name.	Blossomed.	Ripe.	Weight of 25 Berries.	Order of Merit in Weight of Berries.
Agriculturist, . . .	April 3.	May 12,	4¾* ozs.	(1.) Sharpless.
Bidwell, ...	. . . .	May 14,	5¼ ozs.	(2.) May King.
Boone, ...	. . . .	May 14,	4¾ ozs.	(2.) Jersey Queen.
Charles Downing, .	April 16,	May 15,	4½ ozs.	(3.) Ironclad.
Cornelia, ...	April 9.	May 14,	4 ozs.	(3.) Mount Vernon.
Daisy Miller, . .	. . . .	. . . .	4½† ozs.	(3.) Manchester.
Garretson, ...	April 12,	May 14,	4½† ozs.	(4.) James Vick.
Indiana, ...	April 9,	May 11,	5 ozs.	(5.) Bidwell.
Ironclad, ...	March 29,	May 15,	5¾ ozs.	(6.) Indiana.
James Vick, . . .	April 13,	May 14,	5½ ozs.	(6.) Jumbo.
Jersey Queen, . .	. . . .	May 23,	6 ozs.	(7.) Boone.
Jumbo, ...	April 3,	May 14,	5 ozs.	(7.) Jucunda.
Jucunda, ...	April 12,	May 15,	4¾ ozs.	(8.) Primo.
Kentucky, ...	April 13,	. . . .	4 ozs.	(8.) Charles Downing.
Legal Tender, . .	April 14.	. . . .	3¾ ozs.	(9.) Parry.
Longfellow, . . .	April 9,	May 13,	3 ozs.	(9.) Mrs. Garfield.
Manchester, . . .	April 7,	May 15,	5¾ ozs.	(10.) Cornelia.
May King, ...	April 3,	May 12,	6 ozs.	(10.) Kentucky.
Mrs. Garfield, . . .	April 12,	May 16,	4¼ ozs.	(10.) Woodruff.
Mount Vernon, . .	April 14,	May 22,	5¾ ozs.	(11.) Legal Tender.
Parry, ...	April 13,	May 13,	4¼ ozs.	(12.) Longfellow.
Primo, ...	. . .	May 15,	4½ ozs.	
Sharpless, ...	April 2,	May 16,	8¾ ozs.	
Woodruff, ...	April 16,	May 23,	4 ozs.	

* 24 berries. † 20 berries.

In conclusion, we would recommend, in the order given, the following five varieties, on the basis of quality alone: Prince of Berries, Sharpless, May King, Bidwell, Parry. Where combining quality with productiveness, and salability in the market, we recommend the following, in the order given: Sharpless, Jumbo, May King, Indiana, Jersey Queen.